

Reconstruction in MicroBooNE using OpenCV Image Processing



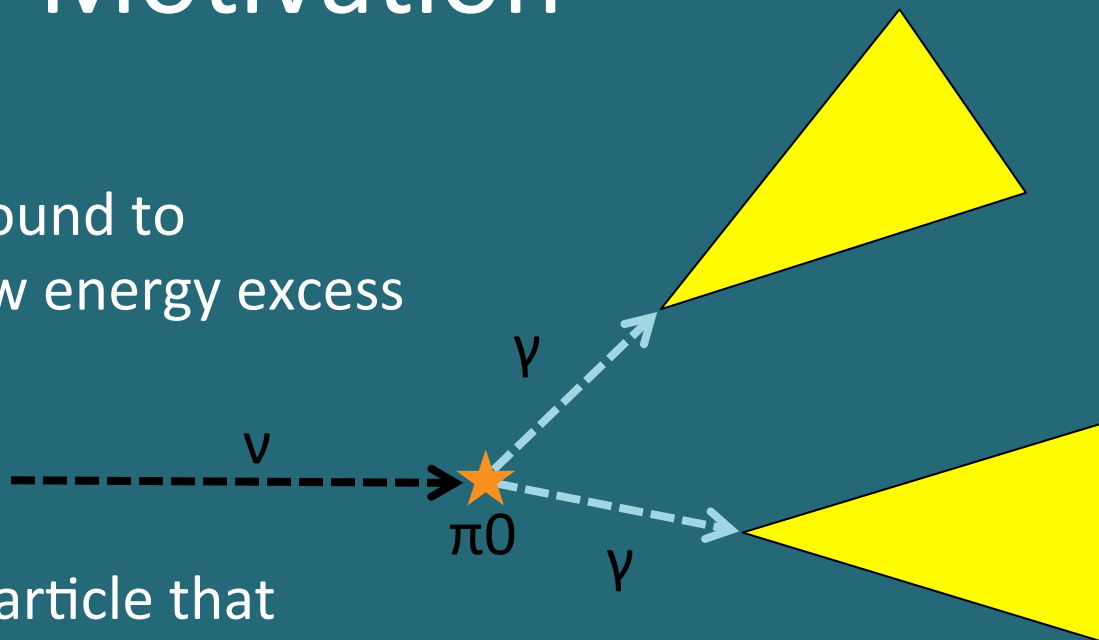
Ariana Hackenburg, Yale University
New Perspectives 2016



Motivation

Why π^0 ?

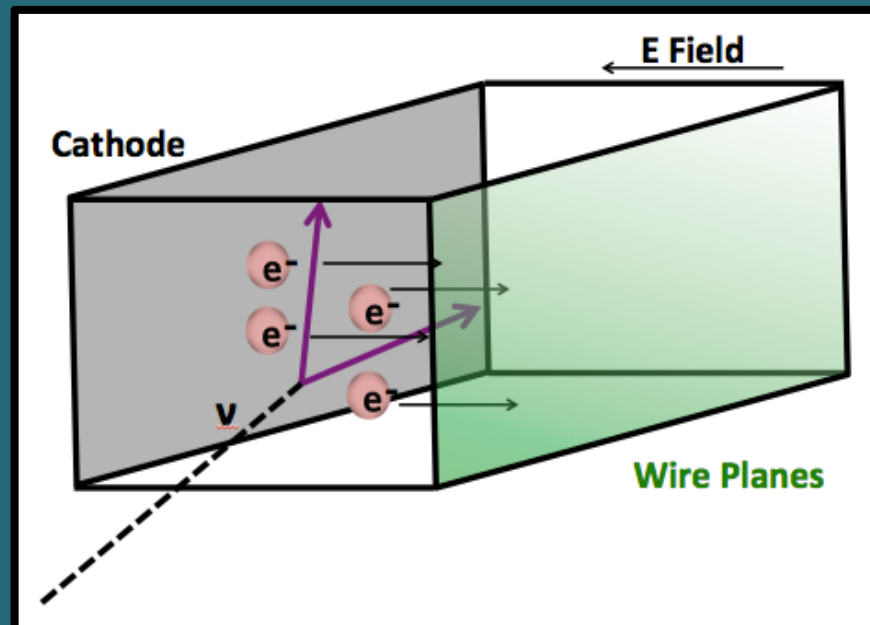
- Important background to understand for low energy excess search
- Can learn about particle that produced electromagnetic showers by looking at shower energies (E_1 , E_2) and 3D opening angle ($\theta_{\gamma\gamma}$)



$$m_{\pi^0} = \sqrt{2E_1E_2(1 - \cos\theta_{\gamma\gamma})}$$

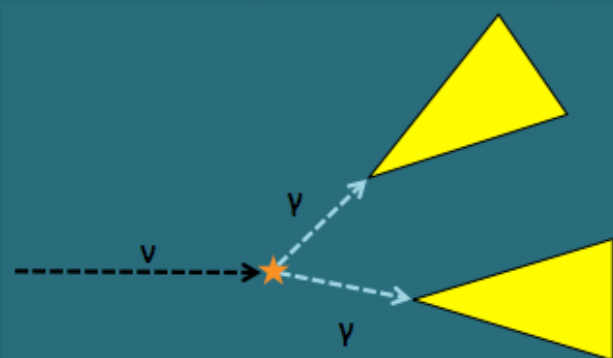
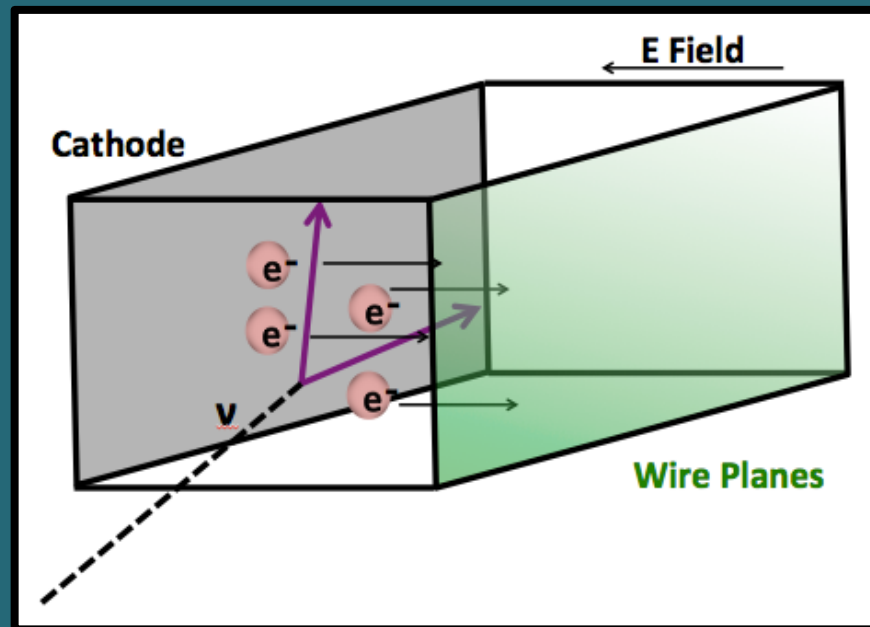
Motivation

- MicroBooNE is a Liquid Argon Time Projection Chamber (see D. Caratelli's talk "MicroBooNE in 10 Minutes")
- Ionization charge drifted to wire planes contains interaction information



Motivation

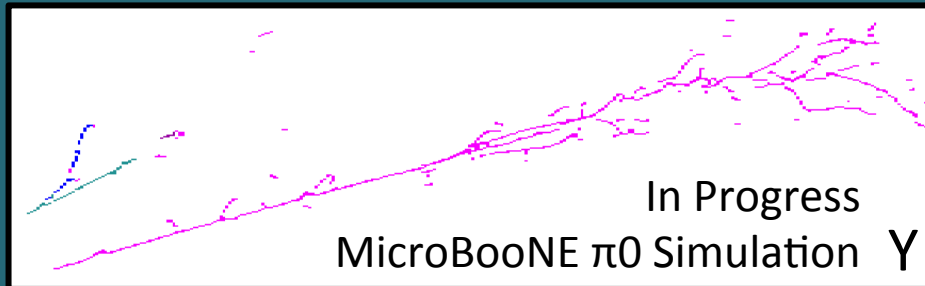
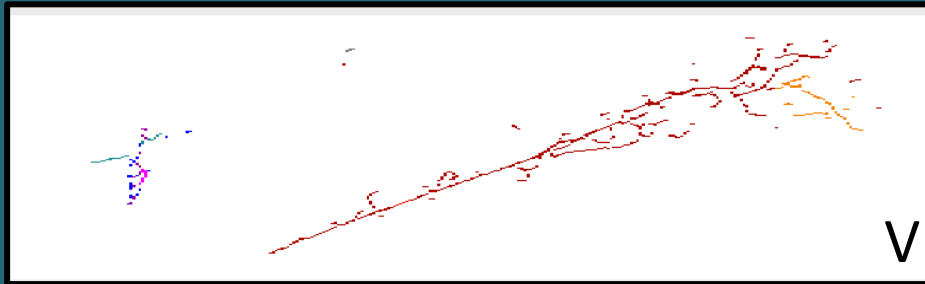
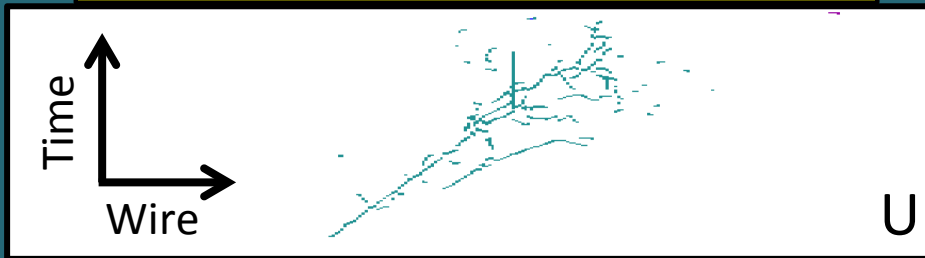
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How can we group **charge depositions** meaningfully?

Motivation – Clustering Example

Traditional (Fuzzy) Clustering



Traditional clustering output suggests many cluster topologies to account for in downstream algorithms

Can we do better?

Note : Colors represent individual clusters and are uncorrelated across planes

Outline

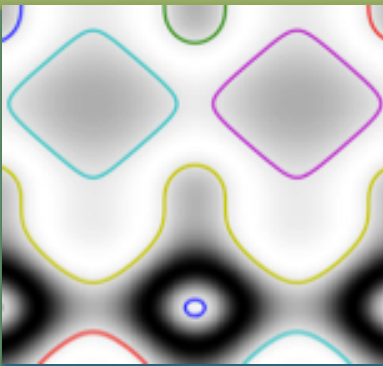
0) Motivation

1) What is OpenCV?

2) Clustering hits with image processing

3) Parameter Finding

4) Reconstruction



What is OpenCV?

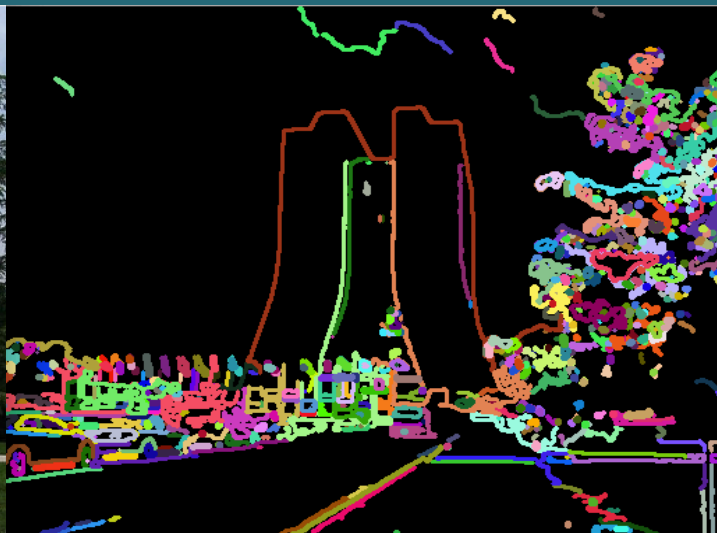


- Open source computer vision library
- Functions and classes to aid in pattern recognition and image processing
- World wide community contributing to algorithm development
- Efficient, fast and easy to use

Examples of OpenCV in Action



Example of
Canny edge
detection



Example of
contour
finding; each
color
represents
contour

Outline

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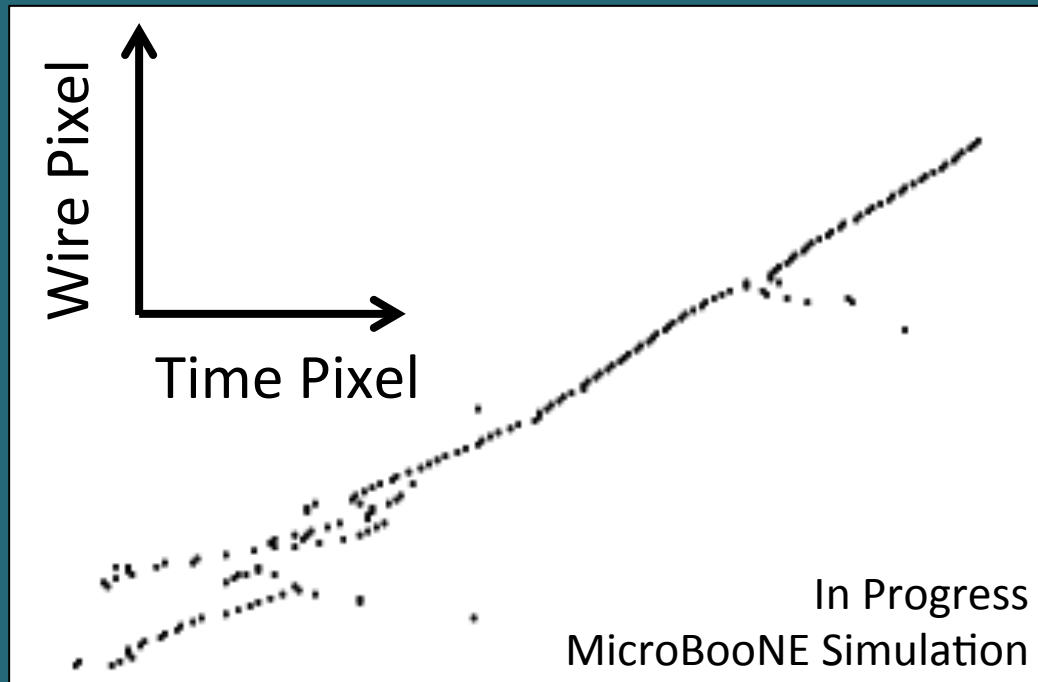
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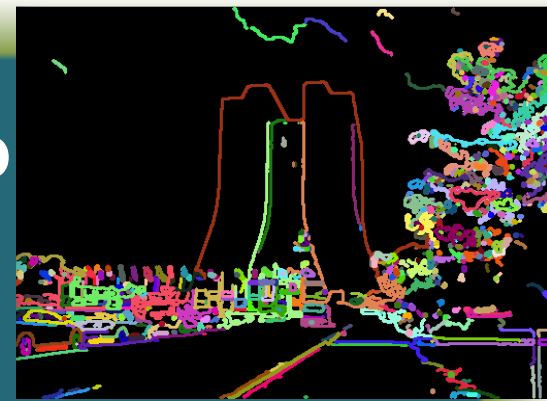
How can we use OpenCV?



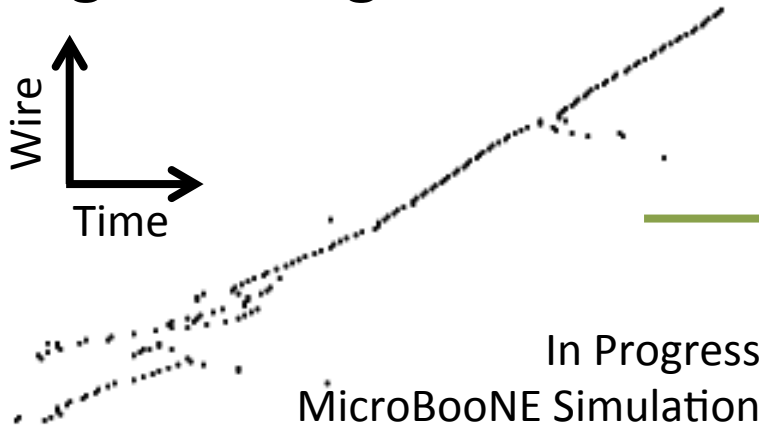
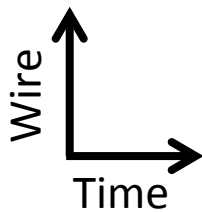
- Size of image determined by wire and time tick ranges
- Scale charge to 8 bits; this results in single channel gray scale image

How can we use OpenCV?

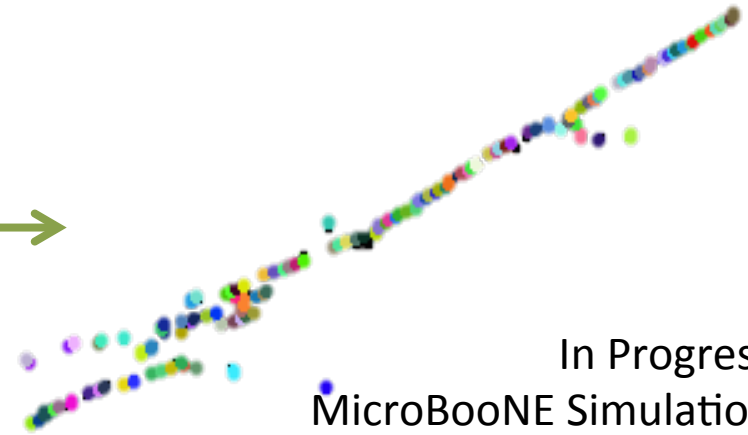
OpenCV Function: “findContours”



Original Image



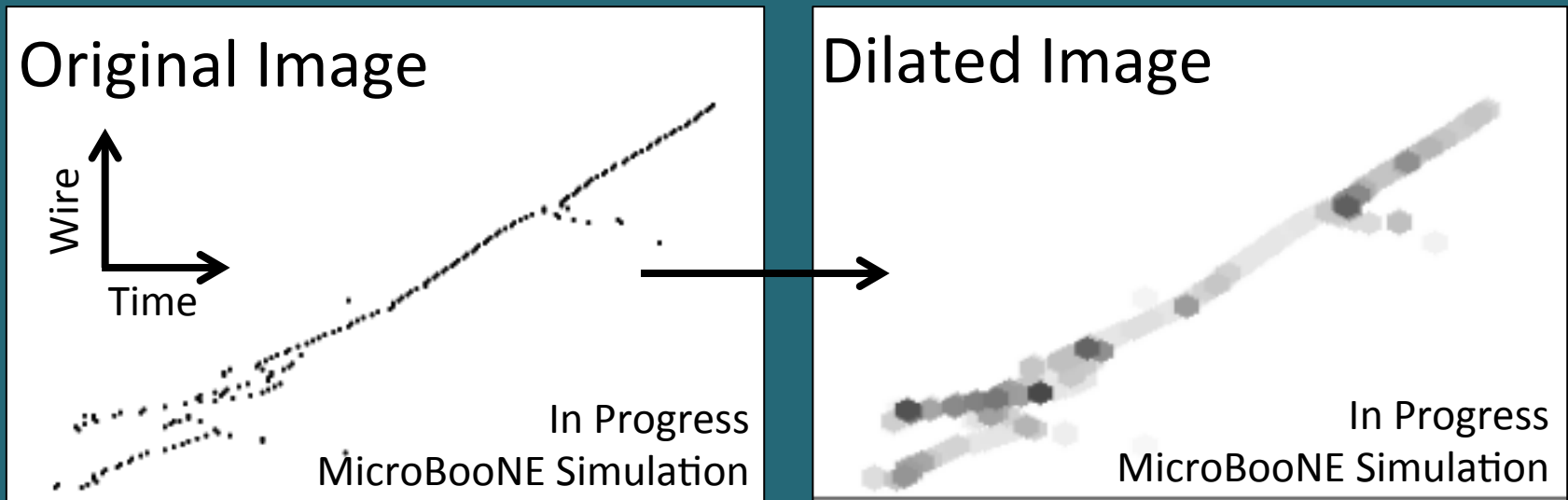
Find Contours



Conclusion: Initial image is too granular; need to manipulate image prior to contour finding

How can we use OpenCV?

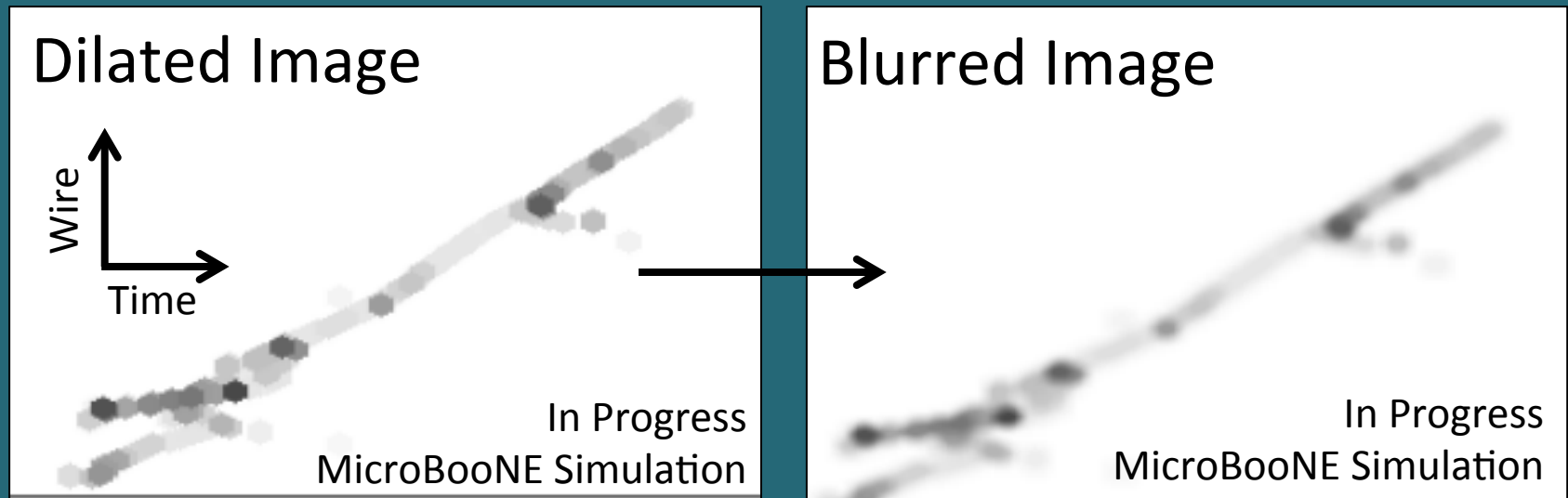
OpenCV Function: “dilate”



Dilation: Set pixels within dilation radius around hit to grayscale value of that hit to connect hits

How can we use OpenCV?

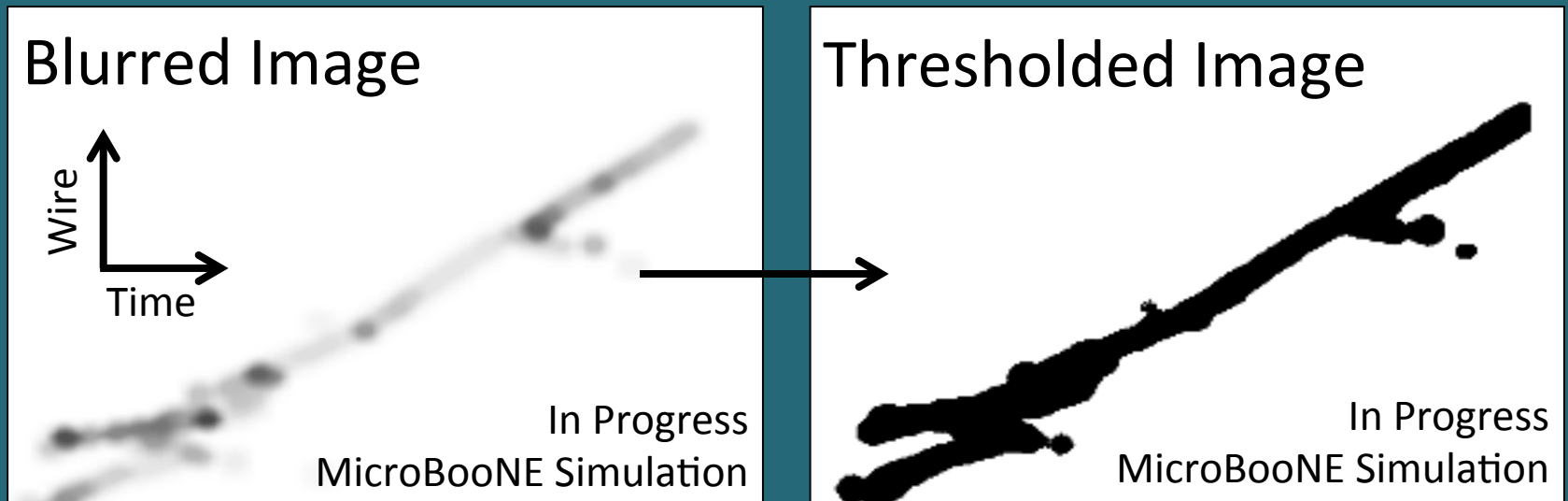
OpenCV Function: “blur”



Blur: Gaussian filter smoothes edges of dilated image

How can we use OpenCV?

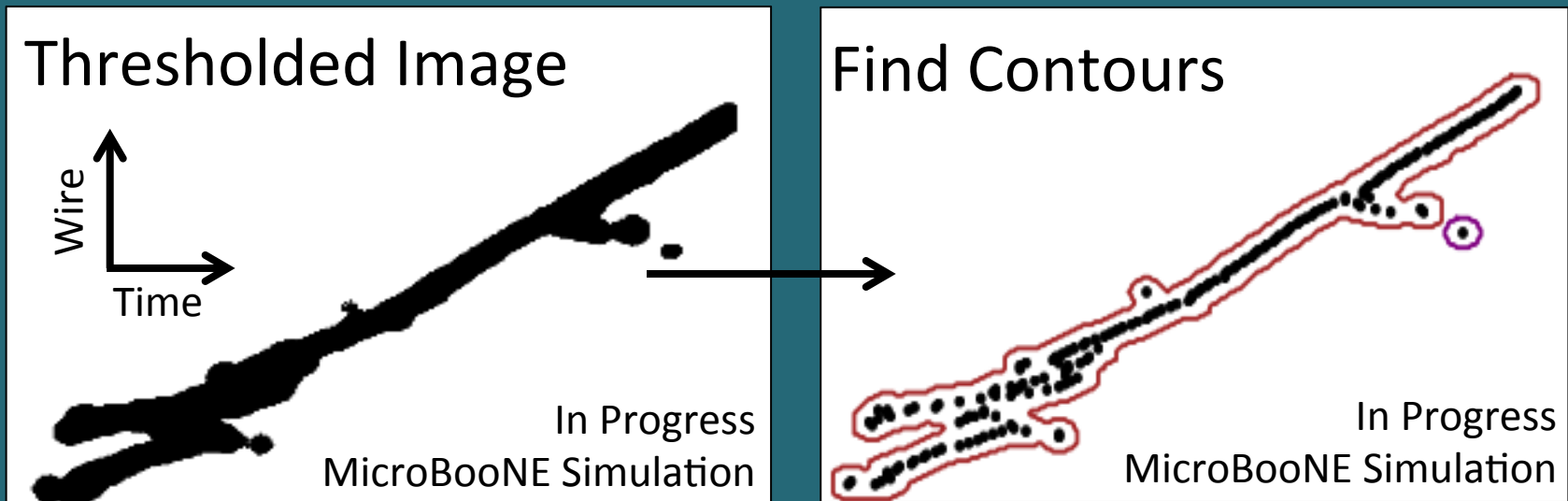
OpenCV Function: “threshold”



Threshold: Convert pixels above some grayscale threshold value to 1's, those below to 0's.

How can we use OpenCV?

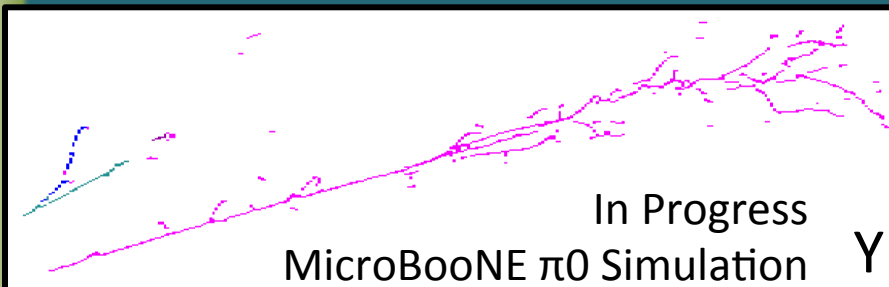
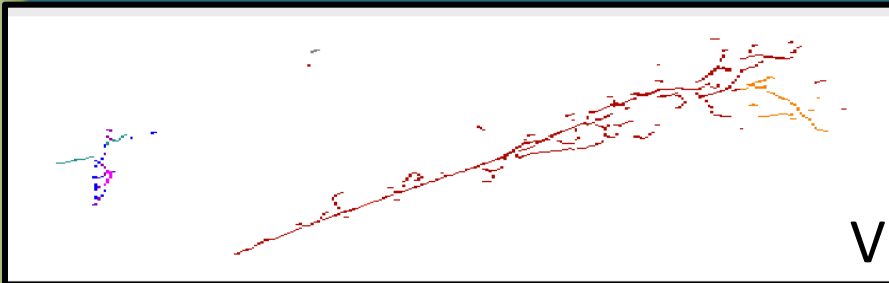
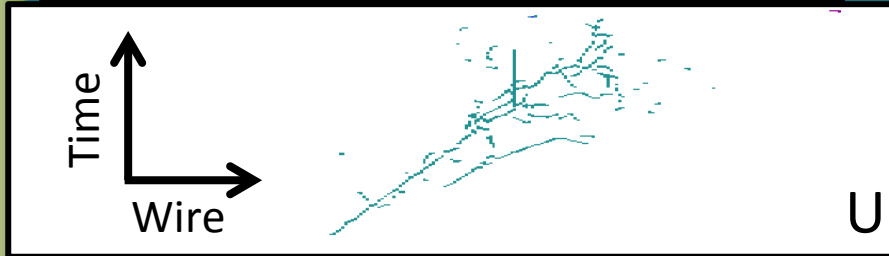
OpenCV Function: “findContours”



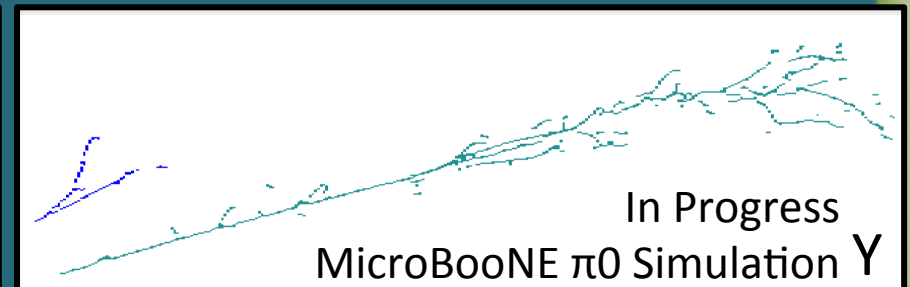
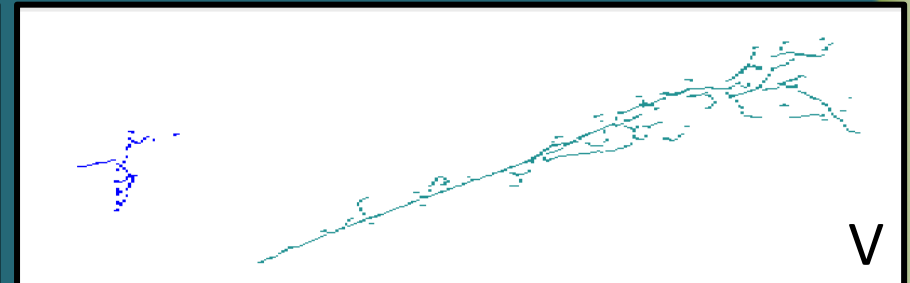
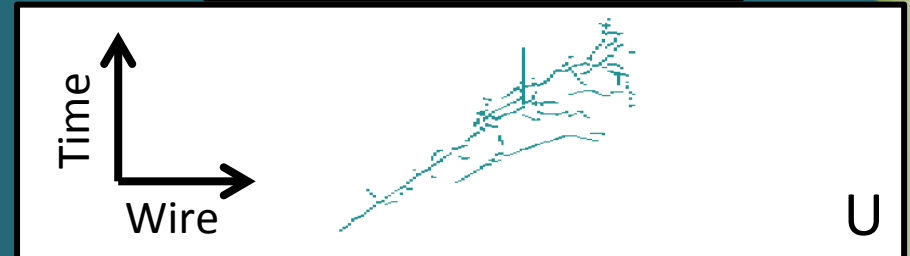
Contours: Lastly, we apply contour finding on the thresholded image and associate pixels to each contour

Clustering Comparison

Traditional (Fuzzy) Clustering



OpenCV Clustering



OpenCV does better job in the first pass of clustering!

Outline

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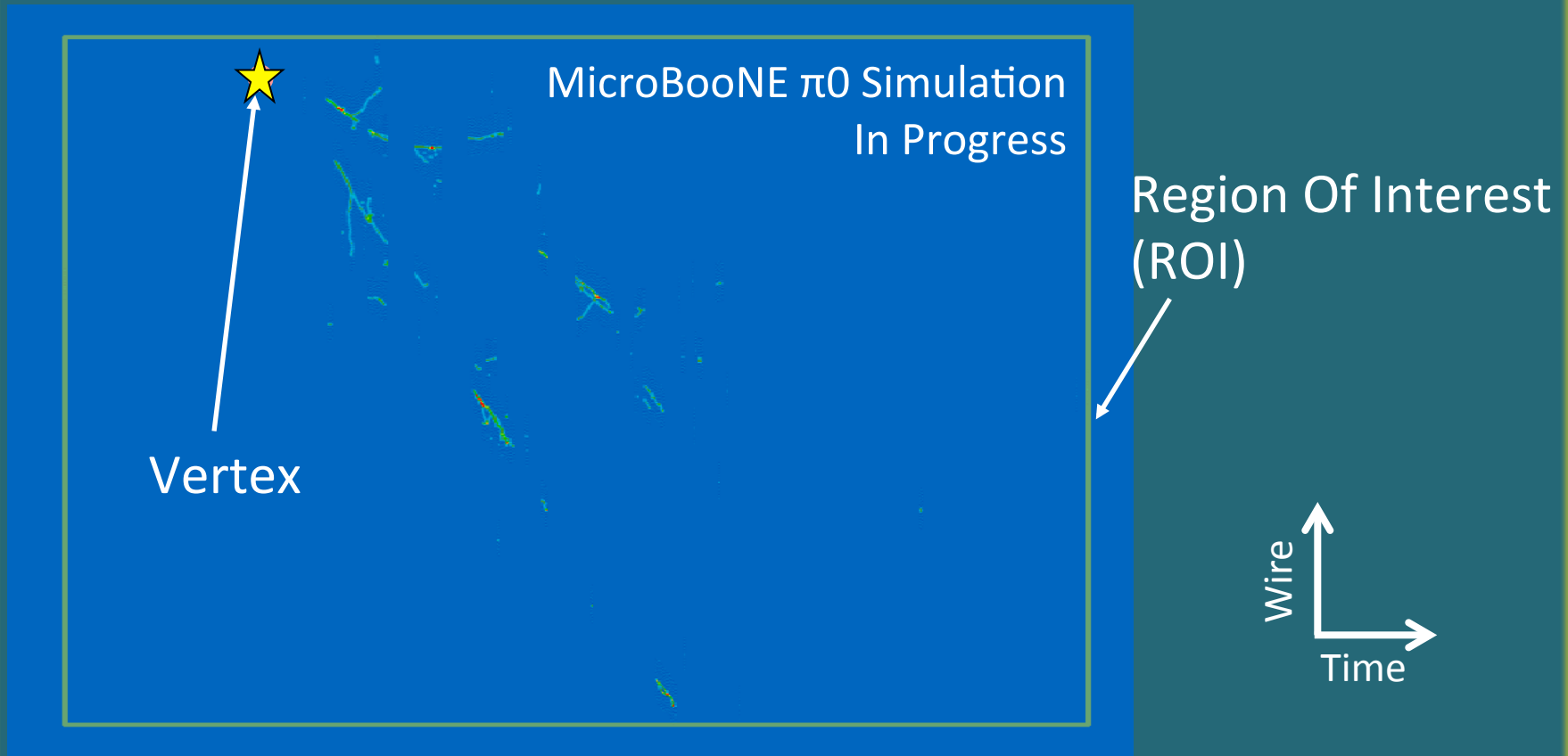
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Parameter Finding – Region Of Interest



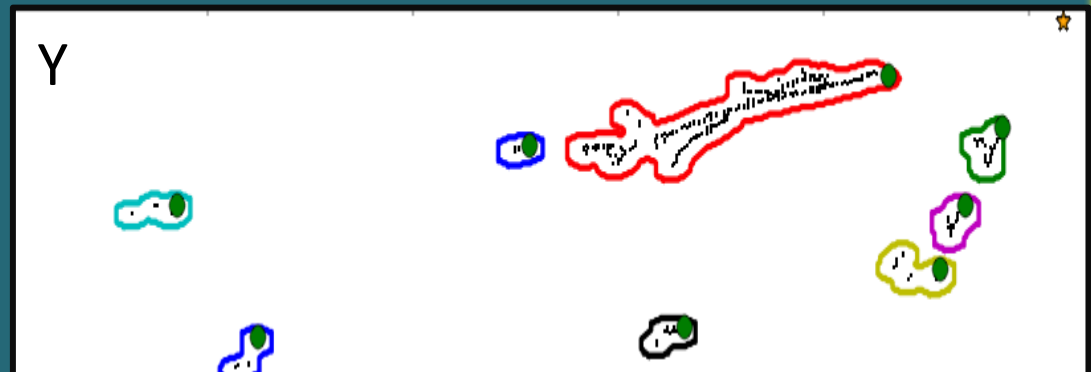
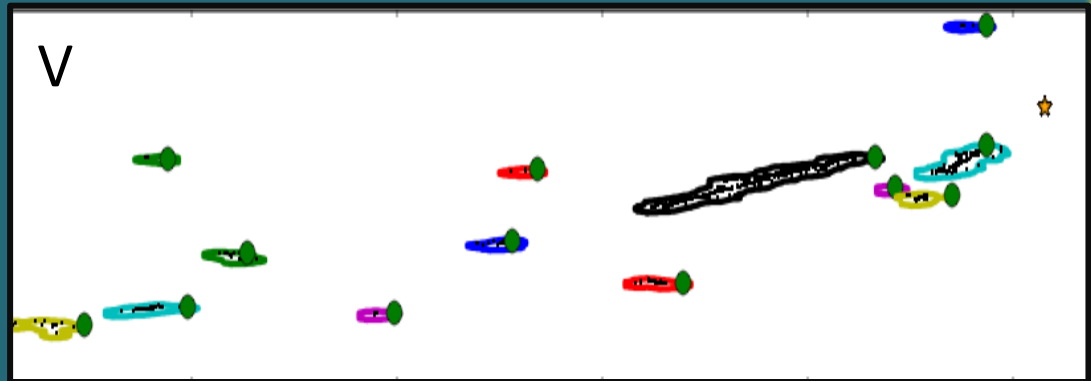
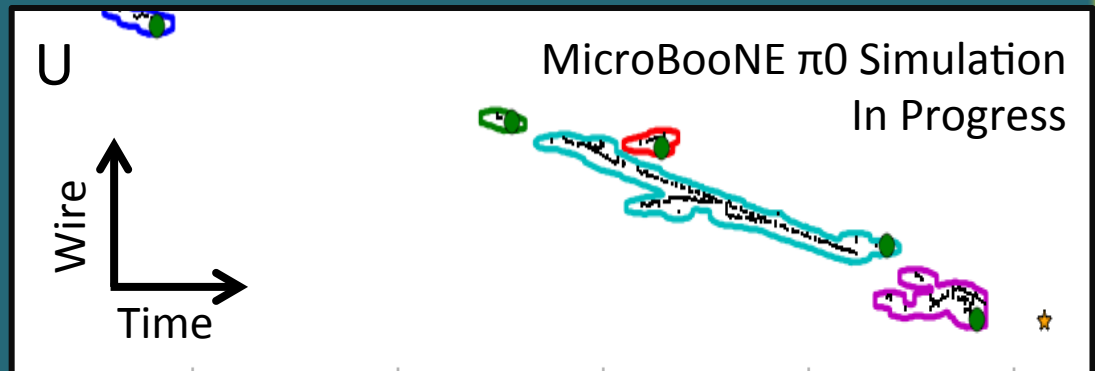
Can deterministically cluster if passed an ROI
by selection algorithms, Deep Learning, etc

Parameter Finding – ROI

Can use interaction vertex from ROI to assign cluster start point, direction

Colors uncorrelated

- ★ ROI Vertex
- Start Point
- Charge

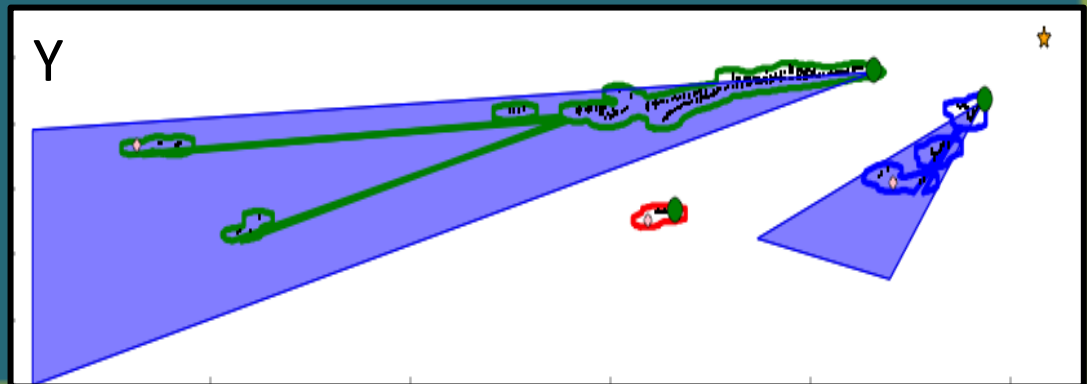
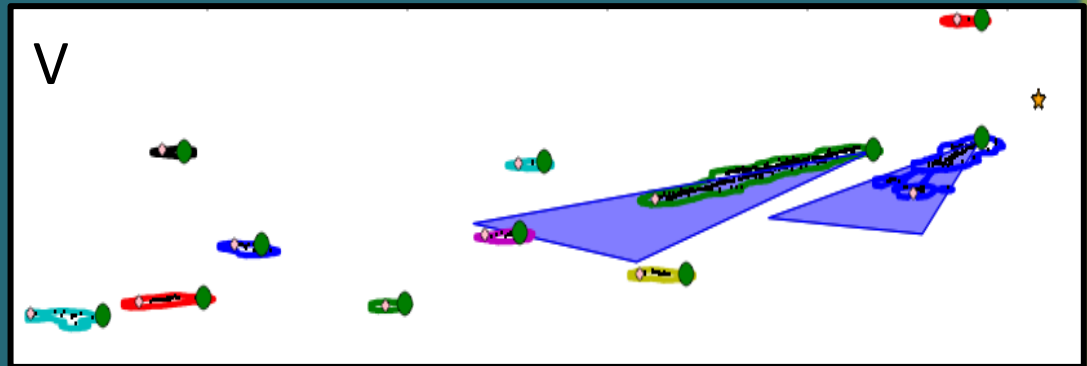
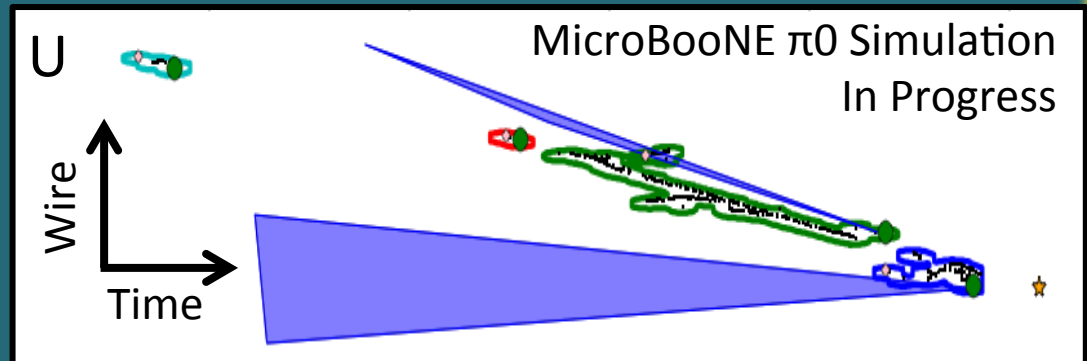


Merge Missing Charge

Expand triangle
from start point
along direction to
merge excess
charge

Colors uncorrelated

- ★ ROI Vertex
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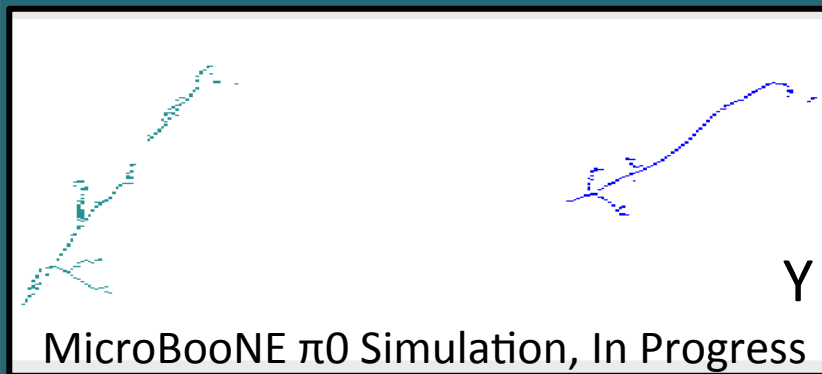
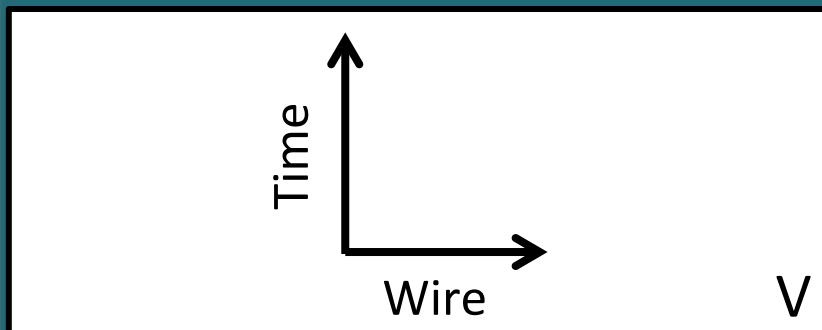
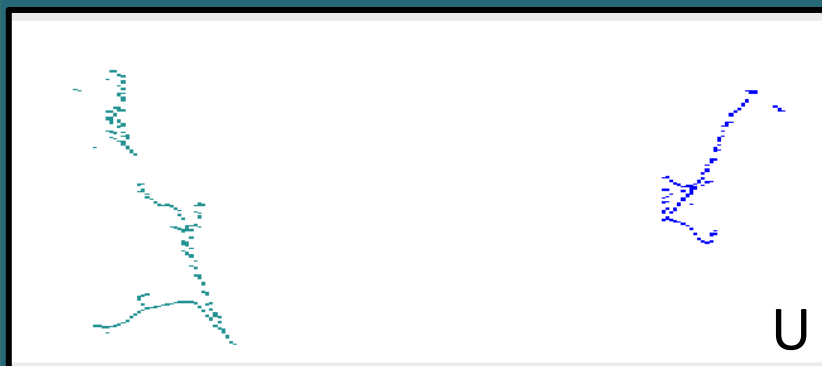
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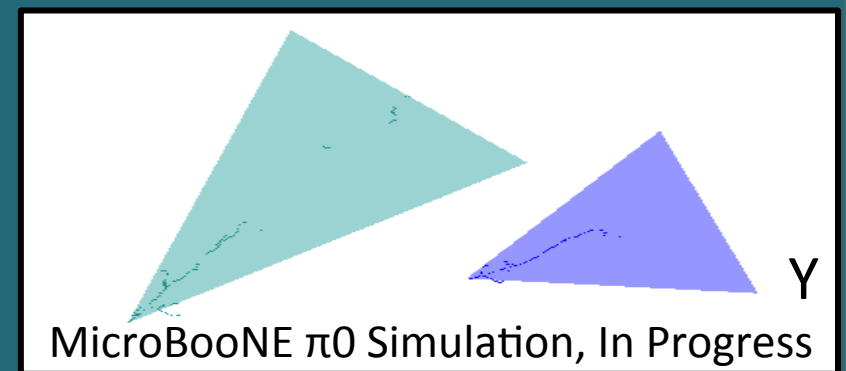
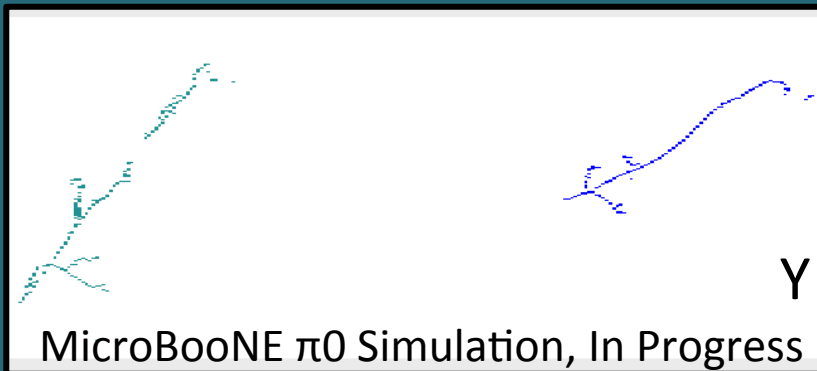
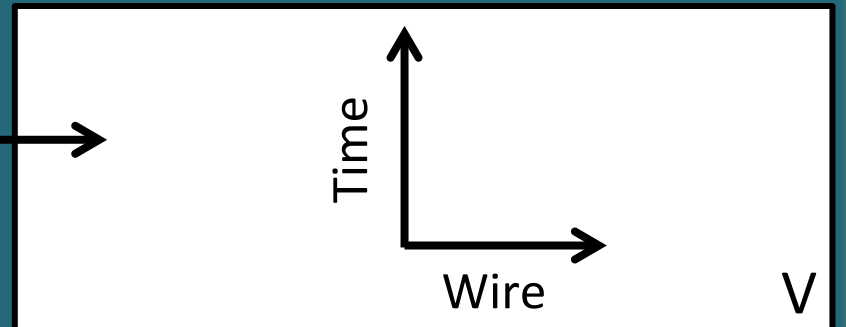
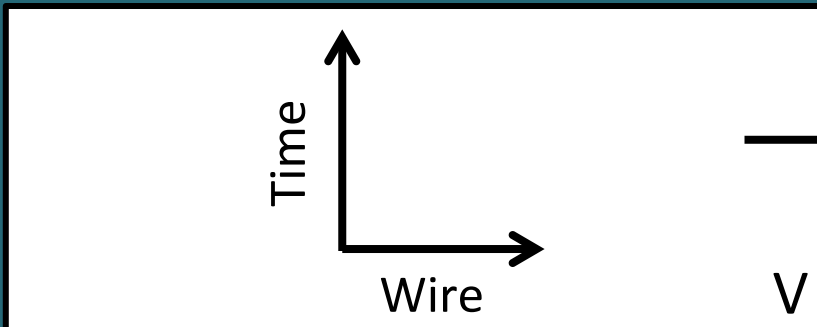
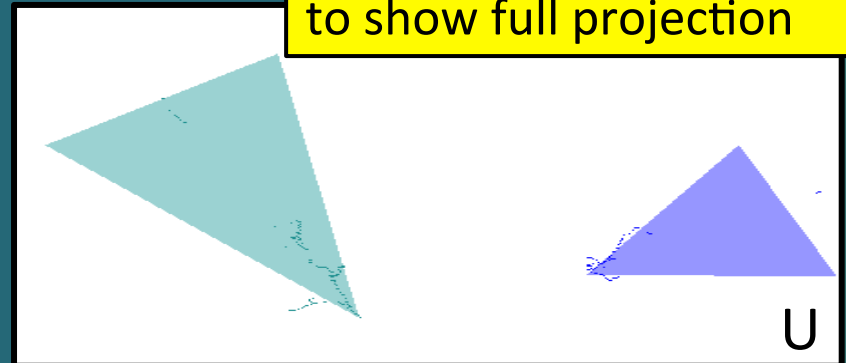
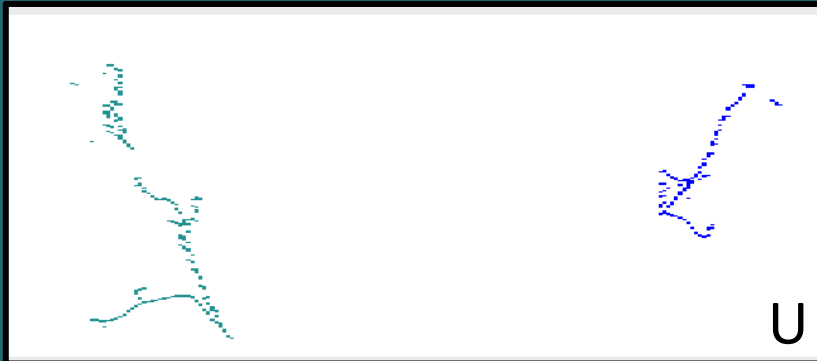
Cluster Matching



- Only need two planes to do reconstruction; in this case, matches are found between planes U and Y
- Clusters matched according to similarity in shared coordinate, time

Reconstruction

Note: View is zoomed out to show full projection



Conclusion

- OpenCV is pattern recognition software with easy to use algorithms and classes.
- We can use OpenCV to manipulate our event images, contour find, and form clusters.
- OpenCV identified clusters can be assigned parameters and successfully reconstructed for use in physics analysis

Thanks!